Small Engines

4-H Leader Resource Manual

Note to 4-H Small Engines Leaders:

This manual is in draft form. It has been printed to assist you with teaching the Small Engines project this year. It will be finalized for the 1999-2000 4-H year. Your comments or suggestions are welcome. Please contact your 4-H Specialist or forward them to:

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4-H PLEDGE

I pledge my head to clearer thinking
my heart to greater loyalty
my hands to larger service
and my health to better living
For my club, my community and my country.

4-H MOTTO

"Learn to do by Doing"

4-H GRACE

(Tune: Auld Lang Syne)

We thank thee Lord for blessings great
On this our own fair land.
Teach us to serve Thee joyfully
With head, heart, health and hands.

Who to Contact

If you have any questions about the 4-H program or this project, contact the 4-H Specialist in your area:

Western Region - Yarmouth, Digby, Annapolis	584-2231
South Shore Region - Lunenburg, Queens, Shelburne	543-0505
Valley Region - Hants, Kings	798-8377
Central Region - Halifax, Cumberland, Colchester	893-6586
Eastern Region - Antigonish, Guysborough, Pictou	755-7150
Cape Breton Region - Richmond, Cape Breton, Inverness, Victoria	563-2000

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Small Engines

Dear 4-H Small Engines Leader:

Welcome to an exciting and enjoyable 4-H project. If this is your first year you must be eager to learn as much about Small Engines as you can.

Welcome to 4-H!

4-H is an organization for rural youth ages 9-21 that is active in countries all over the world! The primary goal is the development of members as individuals and responsible members of society through an appreciation of the agricultural industry and by having fun.

Through the motto Learn To Do By Doing, the 4-H program in Canada aims to help young people:

- Increase their knowledge and develop skills in subject matter areas which are of interest and value to the individual;
- Acquire a positive attitude towards learning;
- Build self-confidence;
- Develop a sense of responsibility;
- Develop the ability to make wise decisions;
- Learn how to work effectively in groups;
- Acquire leadership and communication skills;
- Enlarge their horizons by participating in new experiences.

The name 4-H is derived from the first letter of the four words Head, Heart, Hands and Health; the significance of which is expressed in the 4-H Pledge.

I Pledge
My Head to clearer thinking
My Heart to greater loyalty
My Hands to larger service
My Health to better living
For my club, my community and my country.

What do you need to know to be a Small Engines Project Leader?

The answer is nothing! This resource guide has been designed to give you all the information you need to know. Small engines is a topic highly connected with agriculture and rural life and your participation as a leader will be very rewarding!

4-H IN NOVA SCOTIA

Nova Scotia 4-H has been operating in Nova Scotia since 1922 when the first club was organized in Heatherton, Antigonish County. The provincial and county councils provide the means for direct youth and leader involvement in programming and decision-making. The Nova Scotia Department of Agriculture and Marketing is the sponsor of 4-H.

Nova Scotia has six regions, each managing its own 4-H program through the cooperative efforts of 4-H Specialists, the regional staff of the Nova Scotia Department of Agriculture and Marketing, the county leaders councils and the provincial 4-H office. They help clubs organize, function, learn and develop.

The county council is composed of leaders, junior leaders, and senior members within a county. This body plans and organizes the yearly activities of the area.

The role of a 4-H Project Leader is to help 4-H members understand the topic through activities and projects.....

Have fun while you and your club members are learning together!

The Nova Scotia Department of Agriculture and Marketing in Truro is the administering body of the provincial program and assists each county with resource support.

ACHIEVEMENT DAY

Achievement Day is one highlight of the 4-H club year. Achievement Day allows members to display to the public, the projects they have worked on all year and have them evaluated in a non-competitive manner. They are evaluated on the quality of project work with consideration being given to the member's age and the number of years in 4-H. Each club or county plans, prepares for and holds its own Achievement Day.

Members who participate in public speaking and/or demonstrations will receive recognition for this on their Achievement Day Certificate.

Clubs usually make this event into a community day for the families and friends of the club members. This brings the community closer to 4-H and gives members an opportunity to show their accomplishments.

Any member who receives a project completion at their Achievement Day is then eligible to enter their project into their local exhibition or county show. Winners from the exhibition go on to compete at the Nova Scotia 4-H Show.

Project completion at Achievement Day requires a satisfactory completion of a number of requirements.

Please refer to the Small Engines Project Newsletter of the current 4-H year for detailed information on project requirements, record sheet, judging, club contribution etc.

There are many topics to cover in the 4-H Small Engines Project. 4-H members of all ages will find something to interest them.

As a leader, seeing what the members already know will be important. Briefly review the material they know and then move onto new and interesting topics.

Caution ! This manual is designed as an outline for teaching the Small Engines 4-H Project. It is not designed to replace the owners manual for any particular make or model you may be working on **always consult your owners manual.**

BECOMING A SMALL ENGINES LEADER

We are pleased to have you as a small engines leader! On the surface, leadership would seem to be just planning and organizing. But it's really a chance for you to use your knowledge and interest in working with youth to help them develop individually and achieve their goals. This is a challenging and rewarding experience! The time you spend with youth from your community will be very valuable for everyone involved.

YOUR ROLE AS A VOLUNTEER LEADER

As a volunteer leader you will:

- **!** Plan project meetings and events;
- **!** Provide guidance in completion of projects;
- **!** Provide a fun atmosphere for meetings and activities;
- **!** Encourage members to adopt a positive attitude;
- **!** Challenge the members to do their best;
- **!** Help members set and reach goals;
- **!** Enjoy involvement in 4-H!

Most people would agree that the core of 4-H club work is the project. Through the project, club leaders work with members to help them achieve the objectives of club work. Upon successful completion of a project members will gain:

- **!** A feeling of accomplishment;
- **!** Recognition for their work;
- **!** Self-confidence.

ADVANTAGES OF BEING INVOLVED IN SMALL ENGINES?

- **!** You will help youth learn skills and information about small engines and give them

practical ideas about what they can do to learn more about nature;

- You will help young people further develop an appreciation for their surroundings;
- You will prepare members for citizenship responsibilities through learning to do by doing;
- You will have the opportunity to learn more about small engines through teaching, observing, participating and collecting;
- You will be part of a growing number of people who realize that small engines provides a wealth of activities and learning opportunities for both young and old.

This Small Engines Resource Guide has been designed to help and guide you in teaching the materials associated with Small Engines Projects. Feel free to contact your local 4-H Specialist or Agricultural Representative at any time for additional assistance.

TEACHING THE PROJECT

Most of us would agree that the core of 4-H club work is the project. Traditionally, club work has been organized so that every member takes a specific project. Through the project, club leaders work with members to help them achieve the objectives of 4-H. A member who successfully completes a project will receive:

- A feeling of accomplishment;
- A challenge to his or her abilities;
- Attention from others, mainly through displaying a project at Achievement Day;
- Pride of ownership;
- A sense of responsibility.

The job of the project leader is important. Effective project leadership really begins with the wise selection of projects. Project leaders should help members choose their projects carefully to suit their interests and abilities.

PRINCIPLES OF LEARNING

Project leaders are really teachers. Leaders are therefore concerned with what and how the members **learn**. These principles may be useful to keep in mind.

- **Principle of Activity** - learning is increased when the members **actively** participate (through helping to plan, being a part of the program and through practice sessions).
- **Principle of Transfe**r - things learned in one situation tend to carry over to similar situations. Members may have learned things from another project, in school or in another activity that will help them in the project you are teaching. Find this out and build on it.
- **Principle of Satisfaction** - satisfying results strengthen learning; unsatisfying results weaken

what was learned. If a member is to be satisfied with their project they need to be helped to select one for which they have the ability and in which they show a real interest. Members also need to be taught well and to be encouraged to complete their project. If these needs are not met, they will not be satisfied with the project and will not have learned as much.

- **Principle of Attitude** - a bad attitude toward the project or club work retards learning; a favourable attitude increases learning. A project leader needs to understand the members as individuals to help them develop a favourable attitude.

- **Principle of Rewards** - rewards strengthen and maintain any learning that leads to them. Rewards need not be tangible, such as a prize, a trophy or a ribbon given at the Achievement Day. In fact, most members will need rewards often during the club year rather than only at the end. Rewards can be intangible such as a word of praise from the leader, or recognition from the group during the year.

- **Principle of Frequency** - more frequent presentation increases learning. Project leaders follow this principle by repeating important parts of the project, by reviewing, by using oral and written questions.

- **Principle of Practice** - the old adage "practice makes perfect" is very true in 4-H project work.

- **Principle of Timing** - learning is increased by introducing a fact or skill just before it can be used in a practical way. For example, the members should be taught how to feed their chicks at the start of the project, not at the end, so that they can use the information right away.

IMPORTANT STEPS IN TEACHING

DRAW UP A PLAN FOR THE YEAR

Planning should be done near the beginning of the club year by every project leader. You will decide how many meetings your project group will hold and what topics are to be studied. In planning, decide what will be taught, how and by whom at each meeting. You may want your members to help, particularly older members, and each member in your project group should have a copy of the plan.

CONSIDER YOUR MEMBERS

Before starting to teach it is wise to look at the number of members, their ages and their experience. The size of a project group should not be too great. This will depend on the project,

but generally not trying to teach more than eight is best. If there are more than this in one project the club could consider finding more project leaders or assistants.

As far as possible, the members in one group should be about the same age and/or experience level. For example, teaching a certain topic to a group that contains both 16 year old members with several years experience and 10 and 11 year old members with no experience may be difficult for one leader. In a situation like this, the group should be divided into at least two sections, or the leader could draw on the experience of the 16 year old members in the group.

THE MEETING PLACE

Wherever the club meets, inside or out, at home or in a school, the meeting place should be comfortable. Members cannot concentrate:

- if they are too hot or too cold;
- if there are distracting noises;
- if there are other happenings of interest nearby (such as other project groups);
- if they have to sit or stand for too long at once;
- if they are hungry.

GAIN THE INTEREST OF THE MEMBERS

If leaders are to obtain and keep the members' interest they must become aware of the importance and interest of the topics they are to learn. This is easier with some parts of the project than others since some phases can be related to the members' needs or interests. For example, members may be more interested in working with their chickens but it may be a challenge for the project leader to try to show members the importance of keeping records.

START WHERE THE MEMBERS ARE

At the start of the year find out what it is about the project that interests them, how much they already know and if they have any questions. This will help you know where to start teaching and help avoid teaching above the members' heads or at too elementary a level, both of which can destroy interest. As you teach, make sure the topic being discussed, the words, charts and other teaching tools being used can be understood by all members.

HAVE EVERY MEMBER ACTIVE

Involve as many members as possible through planning, arranging for the meetings and at the meeting itself. Wherever possible, a practice session should follow project instruction, giving every member a chance to become involved. **Experience is the best teacher** and members retain more information if they learn through practical experience. It has been shown that we remember:

- 30 per cent of what we hear;
- 80 per cent of what we see and hear;

C 90 per cent of what we actively participate in.

MAKING TEACHING PRACTICAL

The methods and equipment you use in teaching should be practical in the sense that they may be used by or are available to the members. Wherever possible, use real items in a demonstration rather than pictures. For example, in teaching how to show the chicken, you will want to teach by actual demonstration rather than just talking or only using posters.

USE A VARIETY OF TEACHING METHODS

When doing your planning for the year, consider different ways at presenting the material and choose the method that will be the most suitable. Each method will have advantages in particular situations and a change in teaching methods helps to maintain interest. Your knowledge of members' characteristics at various ages will be a help here. For example, younger members need more frequent changes and more activity to keep their interest. Members in their early and mid-teens like to work in groups, which means you can use panels, role-playing and other group techniques.

PRINCIPLE OF OBJECTIVES

The members should understand and accept the goals of the project.

PRINCIPLE OF PROGRESS

Learning goes best when the learner can see he or she is making progress. Younger members especially may need shorter-term goals so they can see from meeting to meeting how they are progressing, rather than waiting until the Achievement Day. **In all projects, dates should be set for completing parts of the record book.**

PRINCIPLE OF MOTIVATION

No one learns if he/she is not motivated to learn.

Types of motivation for members:

< **Competition** - Competition may act as a motivation to learn for those who feel they have a chance to win the competition, but do not let it get out of hand so that the individual's personal development may suffer.

< **Cooperation and opportunity** for planning the meeting are motives that affect learning.

< **Praise and criticism:**
C A good incentive is praise for work well done;

- Too much or undeserved praise has a bad effect;
- Praise is better than criticism and constructive criticism is better than completely ignoring a learner's efforts;
- Sarcasm and ridicule affect self-esteem.

- To **like and respect** the teacher helps the learning process.

PLACES WHERE THE PROJECT IS TAUGHT

As a project leader you may be involved in teaching the project at various places and at various activities. However, most of your teaching will be done at a project meeting.

PROJECT MEETINGS

The project meeting may follow a general meeting or it may be a specific project meeting for the members in your project group. Following are suggestions to organize the project meeting:

- **Project Reports by Members** - this might be the first item in the meeting. It provides an opportunity for members to report on their project work since the last meeting, to bring up any problems or questions and for the leader to determine their progress, answer questions and make suggestions.

- **Introduction to the Next Topic** - Outline the new topic and the reason for its importance. This is the place to gain the members' interest so that they will be attentive for the next part.

- **Group Instruction** - This is where the actual teaching of the new topic takes place using the best method. This will be done by the project leader, the members or by a special resource person.

- **Group Activity** - This is a practice period in which the members do something. If possible, they should practice what has been taught. If not, they may work on record books or practice demonstrations.

- **Individual Help** - while the group activity is going on, the leader may help those who need it.

- **Preparing for the Next Meeting** - here the leader may give instruction on homework to be done, items to bring to the next meeting and so on.

This resource guide contains units with a small engines theme. Each unit contains the following:

Project record sheets and small engines 4-H Project Newsletter are extra supplements to this resource guide.

AUDIO VISUAL RESOURCES AVAILABLE

Audio visual resources are available through the Provincial 4-H office in Truro on a two-week loan period. To book slides or videos, call (902) 893-6585 and give the title and number of each requested. Please contact your general leader for a more detailed listing of what slides and videos are available. Please give the dates needed and return them by the date specified.

Principals Of Operation

Carbureting

The basic purpose of a carburetor is to produce a mixture of fuel and air on which an engine will operate; to do so relatively easy. However, producing economic fuel consumption and smooth engine operation over a wide range of speeds creates the need for more complicated mechanism than a more mixing valve. There is an additional problem in that the price of such a carburetor must be held in proportion to the price of the engine. The price of a small gas lawn mower engine is not much greater than the price of the carburetor on an automobile.

Keeping this in mind, we utilize the force of atmospheric pressure and the principles of the venturi and the airfoil.

Atmospheric pressure may vary slightly due to altitude or temperature, it is a constant potent force which tends to equalize itself in any given area. It is the weight of the air in the atmosphere pushing down and outward in all directions and is commonly figured as between 13 to 15 pounds per square inch. We know that air moves from a high pressure area to a low pressure area.

Figure 1.1

To use this force of atmospheric pressure in a carburetor, we artificially create low pressure areas and thus obtain movement either of air or of intervening fuel. This will be illustrated later in the manual.

The greater the difference in pressure between the two areas the greater the velocity or the greater the distance we can raise the fuel.

In the interest of terseness we often use the terms vacuum or suction when we actually mean the difference in pressures.

Venturi

What is a venturi? Have you ever noticed that the wind blowing through a narrow space between two buildings always seems to be much stronger than in the open? In other words, the velocity is greater. The same thing can be seen in a river. The current is always faster in a narrow, shallow place than in the deep wide pools.

In a fashion, these narrow places are ventures. The great bulk of air or water suddenly forced through a constructed space has to accelerate in order to maintain the volume of flow.

This is the way a venturi is placed in a carburetor. Fig. 1.2. The shape is carefully designed to produce certain air flow patterns.

Figure 1.2

Airfoil

Now, what is an airfoil? Here is a picture of a tube in an air stream. When still, the pressure is equal on all sides. Under movement, an air pattern is formed. Fig. 1.3, so that we have a high pressure area and a very low pressure area.

Now how does all this apply to small gas engines that may employ one of four types of carburetors, the Flo-Jet (gravity feed or float type), the Vac-Jet (suction feed), the newer Pulsar-Jet (fuel pump) or the Mikuni type carburetor?

Figure 1.3

Flo-jet Carburetors or Gravity Feed

First, let us consider the gravity feed system. The tank is above the carburetor and fuels flows by gravity. Notice an air vent hole in the tank cap so that air can flow in as fuel flows out and a air vent hole in the carburetor bowl so that air can flow out as fuel flows in. If one or both of these holes were plugged, the flow of fuel would cease and stop the engine, Fig. 1.4 and 1.5.

As the fuel enters the bowl, it raises the float. The float in turn raises the needle in the float valve. When the needle touches the seat, it shuts off the fuel flow, and the position at this time is called the float level.

Figure 1.4

Float Level

The float level in general should be high enough to afford an ample supply of fuel at full throttle and low enough to prevent flooding or leaking.

To set the level on the carburetor, invert the upper body as shown, Fig. 1.5. The float and the body cover should be parallel. If not, bend the tang on the float to obtain this position. The actual distance in the small carburetors is 5/16 of an inch between the float and the gasket. On the larger models it is 3/16 of an inch. The float level is not as critical as on some carburetors. Remember, however, that there should be one gasket between the float valve seat and the carburetor.

Figure 1.5

Now, the fuel is down into the bowl but how does it get into the cylinder?

Fig. 1.5 shows the position of the nozzle and the fuel level. The fuel in the bowl seeks its own level, which is well below the discharge holes. Notice that the discharge holes are in the venturi, the place of greatest air velocity. As the piston in the cylinder moves down with the intake valve open, it creates a low pressure area that extends down into the carburetor throat and venturi. Two things start to happen.

Figure 1.6

The air pressure above the fuel in the bowl pushes the fuel down in the bowl and up in the nozzle to

the discharge holes. At the same time the air rushes into the carburetor air horn and through the venturi where its velocity is greatly increased.

The nozzle expending though this air stream acts as an airfoil, creating a still lower pressure area on the upper side. This allows the fuel to steam out of the nozzle through the discharge holes into the venturi where it mixes with the air and becomes a combustible mixture ready for firing in the cylinder.

A small amount of air is allowed to enter the nozzle through the bleeder. This air compensates for the difference in engine speed and prevents too rich a mixture at high speed.

The story of carburetion could end right here if the engine were to run at only one speed and under ideal conditions. However, since smooth economical operation is desired at varying speeds, some additions must be made to the carburetor.

The ideal combustion mixture is about 14 or 15 pounds of air, in weight, to one (1) pound of gasoline. Remember that an engine operating under heavy load requires a richer mixture than under light load. In order to regulate the mixture, we place in the carburetor a threaded needle valve with a tapered point which projects into the end of the nozzle, Fig. 1.5.

To adjust the carburetor for maximum power, run the engine at the desired operating speed, then turn in the needle valve until the engine slows down, which indicates a lean mixture. Note the position of the needle valve, then turn the needle valve out until the engine speeds up and then slows down, which indicates a rich mixture. Note the position of the needle valve, then turn the needle valve to midway between the lean and rich position. Adjust the mixture to the requirement for each engine. Remember that too lean a mixture is not economical. It causes overheating, detonation, and short valve life. Also, since there is no accelerator pump, the mixture must be rich enough so that the engine will not stop when the throttle is suddenly opened. Engines which run at constant speeds can be slightly leaner than those whose use requires changes in speed.

The inset of Fig. 1.5 shows what happens when the needle valve is turned too far. A square shoulder is produced on the taper. It is possible, of course, to adjust the carburetor with the needle valve in this condition, but it is quite difficult, because a small movement of the needle makes a big difference in the amount of fuel that can enter the nozzle. And, if it is not adjusted, vibration can soon throw it off.

Figure 1.7

To allow for different speeds, a flat disc called a butterfly, mounted on a shaft, is placed in the carburetor throat above the venturi. This is called the throttle, Fig. 1.7.

The throttle in the wide open position does not affect the air flow to any extent. However, as the throttle starts to close, it restricts the flow of air to the cylinder and this decreases the power and speed of the engine. At the same time it allows the pressure in the area below the butterfly to increase. This means that the difference between the air pressure in the carburetor bowl and the air pressure in the venture is decreased, the movement of the fuel through the nozzle is slowed down; thus the proportion of fuel and air remain approximately the same. As the engine speed slows down to idle, this situation changes.

At idle speed the throttle is practically closed, very little air is passing through the venture and the pressure in the venturi and in the float bowl are about the same. The fuel is not forced through the discharge holes, and the mixture tends to become too lean.

Idle Valve

To supply fuel for the idle, the nozzle is extended up into the idle valve chamber. It fits snugly in the upper body to prevent leaks. Because of this tight fit, the nozzle must be removed before upper and lower bodies are separated, or the nozzle will be bent.

The idle valve chamber leads into the carburetor throat above the throttle. Here the pressure is low, and the fuel rises in the nozzle past the idle valve and into the carburetor throat through the discharge slot. The amount of fuel is metered by turning the idle valve in or out until the proper mixture is obtained. Here again we see what happens if the needle is screwed in too far. A damaged idle value can result.

Adjustment of the idle valve is similar to that of the needle valve but should be made after the needle valve has been adjusted. The idle speed is not the slowest speed at which the engine will run. On small engines it is 1750 RPM. On larger engines the idle speed may be as low as 1200 RPM. Use a tachometer to set the speed.

Turn the idle speed adjusting screw (located on throttle shaft) until the desired idle speed is obtained and hold throttle closed. Turn the idle valve in until speed decreases, then out until speed increases and again decreases. Then turn the idle valve to a point midway between these two settings. Usually the idle speed adjusting screw will have to be reset to the desired idle speed.

Figure 1.8

The next problem is starting the engine in different temperatures and with different fuels. A butterfly, mounted on a shaft, is placed in the air horn. With this choke we can close, or almost close, the air horn and get a low pressure area in the venturi and throat, Fig. 1.8.

Thus, a rush of fuel is obtained from the nozzle with a relatively small amount of air. Even with low vaporization this extra rich mixture will give easy starting. Only a portion of the fuel will be consumed while choking, and a large portion will remain in the cylinder. This raw gasoline will dilute the crankcase oil and may even cause scuffing due to washing away of the oil film from between the piston rings and the cylinder wall. For this reason, prolonged choking should be avoided.

Vacu-Jet Carburetors

Now let us take a look at the Vacu-Jet system. Here the fuel tank is below the carburetor, so obviously the fuel will not flow by means of gravity. Therefore, the force of atmospheric pressure must be employed.

Again we have a hole in the fuel tank cap to allow the pressure in the tank to remain constant. Now here is something important. Before adjusting the carburetor, put in enough fuel to HALF fill the tank. The distance the fuel has to be lifted will affect the adjustment. At half full we have an average operating condition, and the adjustment will be satisfactory if the engine is running with the tank full or nearly empty.

Figure 1.9

As the piston goes down in the cylinder with both the intake valve and the throttle open, a low pressure area is created in the carburetor throat. A slight restriction is placed between the air horn and the carburetor throat at the choke. This helps to maintain the low pressure.

The difference in pressure between the tank and the carburetor throat forces the fuel up the fuel pipe, past the needle valve, through the two discharge holes. The throttle is relatively thick, so we have, in effect, a venturi at this point, thus aiding vaporization. A spiral is placed in the throat to help acceleration and also to help keep the engine from dying when the throttle is opened suddenly.

The amount of fuel at operating speed is metered by the needle value and seat. Turning the needle valve in or out changes the setting until the proper mixture is obtained. This adjustment must always be done while the engine is running at operating speed, not at idle speed. While the needle valve may look like an idle valve due to its position, it is a true high speed mixture adjusting valve.
Since no accelerator pump is used on this carburetor and since many of these engines are used on lawn mowers where rapid acceleration is needed, the mixture should be rich. Turn the needle value in until the engine begins to close speed, indicating a lean mixture. Then, open the needle valve past the point of smooth operation until the engine just begins to run unevenly. Since this setting is made without load, the mixture should operate the engine satisfactorily under load.

These carburetors do not have an idle valve, but the mixture at idle speed is controlled in a different way. As the throttle closed to idle, the leading edge takes a position between the two discharge holes. The larger of the discharge holes is now in the high pressure area, and the flow of fuel through it will cease. The small hole will continue to discharge fuel but the amount will be metered by the old size and will be in proportion to the reduced air flow. For this reason it is important that the small discharge hole be of the proper size. The needle valve will allow much more fuel to pass than should go through the small discharge hole. A number 68 drill can be used to check the larger hole. This can be done with the needle valve and seat removed, Fig.1.10.

You will notice a small section is milled out of the throttle where it meets the discharge hole. This concentrates the flow of air past the hole and assures good vaporization.

The idle speed adjusting screw should be set to obtain an idle speed of 1750 RPM. This may seem fast to people accustomed to auto engines, but it is necessary in order to have fast acceleration. It also helps cooling and lubrication. A slight unevenness may be noticed at idle speed, but this is normal and no readjustments of the needle valve should be made.

Figure 1.10

The choke is the sliding plate mounted at the outer end of the carburetor, Fig. 1.10 and 1.11. The choke is pushed in to close the air intake for starting but should be pulled out as soon as the engine starts. The use of this choke could be understood clearly. Many complaints of engine trouble, upon investigation prove to be nothing more than failure to properly use the choke, especially where the choke is operated by remote control. The choke must close fully.

The latest engines with Vacu-Jet carburetors incorporate a ball check in the fuel pipe which assures a steady flow of fuel to the needle valve and discharge holes.

Figure 1.11

Pulsa-Jet Carburetors

The Pulsa-Jet is a full carburetor incorporating a diaphragm type fuel pump and a constant level fuel chamber.

The fuel tank, the fuel pump and the constant level fuel chamber serve the same functions as the gravity feed tank, the float and the float chamber of conventional "float type" carburetors.

Figure 1.12

This new design makes it possible to obtain just as much horsepower from the Pulsa-Jet carburetor as is obtained from more complex "float type" carburetors. This is due to the fact that the Pulsa-Jet provides a constant fuel level directly below the venturi as illustrated in Fig. 1.12 thru 1.16. With this design, very little fuel "lift" is required to draw gasoline into the venturi. The venturi can be made larger, permitting a greater volume of fuel-air mixture to flow into the engine with a consequent increase in horsepower.

Figure 1.13

Vacuum created in the carburetor elbow by the intake stroke of the piston pulls cap A and pump diaphragm B inward and compresses spring C, Fig. 1.14.

The vacuum thus created on the "cover side" of the diaphragm pulls gasoline up suction pipe S and under intake valve D into the pocket created by the diaphragm moving inward, Fig. 1.14.

Figure 1.14

When engine intake stroke is completed, spring C pushes plunger A outward. This causes gasoline in the pocket above the diaphragm to close inlet valve D and open discharge Valve E. The fuel is then pumped into fuel cup F, Fig. 1.15.

Figure 1.15

On the next intake stroke the cycle is repeated and this pulsation of the diaphragm keeps the fuel cup full.

The venturi of the carburetor is connected to intake pipe which draws gasoline from the fuel cup F, Fig. 1.16.

Figure 1.16

Since a constant level is maintained in the fuel cup, the engine gets a constant air-fuel ratio no matter what fuel level exists in the main tank.

From this point on, the carburetor operates and is adjusted in the same manner as is the Vacu-Jet carburetor except that the fuel tank does not have to be half full as in the Vacu-Jet. It can be full or almost empty and the adjustment will be the same since the fuel level in the small cup is always the same. There are no valve checks in the fuel pipes. The flaps on the diaphragm serve as valves.

Mikuni Type Carburetor

All models are equipped with slide type Mikuni carburetors. Refer to Tables 1.22-1.25 for carburetor identification and specifications. The Mikuni carburetor are often found on snowmobiles and motorcycles.

A hand-operated choke lever located on the bowl is used for cold starting. Fuel is supplied by a remote pulse type fuel pump.

The carburetors installed on all models consist of several major systems. A float and float valve mechanism maintain a constant fuel level in the float bowl. The pilot system supplies fuel at low speeds. The main fuel system supplies fuel at medium and high speeds. Finally, a choke system supplies the rich mixture needed to start a cold engine.

Figure 1.20 Figure 1.21

Float Mechanism

To assure a steady supply of fuel, the carburetor is equipped with a float valve through which fuel flows by the pulse operated fuel pump into the float bowl (Figure 1.21). Inside the bowl is a combined float assembly that moves up and down with the fuel level. Resting on the float frame is a float needle, which rides inside the float valve. The float valve regulates fuel flow into the float bowl. The float needle and float valve contact surfaces which are accurately machined to insure correct fuel flow calibration. As the float rises, the float needle rises inside the float valve and blocks it, so that when the fuel has reached the required level in the float bowl, no more fuel can enter.

Pilot and Main Fuel Systems

The carburetor's purpose is to supply and atomize fuel and mix it in correct proportions with air that is drawn in through the air intake. At primary throttle openings (from idle to 1/8 throttle), a small amount of fuel is siphoned through the pilot jet by suction from the incoming air (Figure 1.22).

Figure 1.22

As the throttle is opened further, the air stream begins to siphon fuel through the main jet and needle jet. The tapered needle increases the effective flow capacity of the needle jet as it rises with the throttle slide, in that it occupies decreasingly less of the area of the needle jet (Figure 1.23).

Figure 1.23

In addition, the amount of cutaway in the leading edge of the throttle slide aids in controlling the fuel/air mixture during partial throttle openings.

At full throttle, the carburetor venturi is fully open and the needle is lifted far enough to permit the main jet to flow at full capacity. See figure 1.24 and Figure 1.25.

Figure 1.24 Figure 1.25

Carburetor Removal/Installation

1. Open the shroud.
2. Remove the air box.
3. Label the hoses at the carburetors and disconnect them. Plug the hoses with golf tees to prevent fuel leakage and contamination.
4. If necessary, loosen the carburetor caps and remove the throttle valve assembly from the carburetor body.

CAUTION

Handle the throttle valve carefully to prevent from scratching or damaging the valve and needle jet.

5. Loosen the hose clamps at the intake manifolds.
6. Remove the carburetor.
7. Installation is the reverse of these steps.
8. Make sure the fuel hoses are properly connected to prevent a fuel leak.
9. Make sure the air hoses are properly positioned and the hose clamps tightened securely to prevent an air leak.

WARNING

Do not start the engine if the fuel hoses are leaking.

Intake Manifolds:

The intake manifolds should be inspected frequently for damage that could cause a lean fuel mixture.

Governing

While some people think that a governor on an engine is to prevent over speeding, the real purpose in the small engine field is to maintain a desired speed regardless of load. With a fixed throttle position, the engine could speed up if the load was lightened, if the load is increased the engine would slow down or even stop.

A governor on the other hand will close the throttle if the load is lightened or open the throttle to obtain more power if the load is increased.

Basically, governors consist of two types - the pneumatic or air vane type, fig. 1.18 and the mechanical or flyball weight type, Fig. 1.19.

The pneumatic governor as illustrated in Fig. 1.18 is operated by the force of the air from the flywheel fins. When the engine is running, the air from the fins pushes against the air vane. The air vane is connected to the carburetor throttle by means of a link. The force and movement of these parts tends to close the carburetor and thus slow down the engine speed.

Opposed to this is the governor spring which tends to pull the opposite way, opening the throttle. This spring is usually connected to an adjustable control of some kind so that the tension on the spring will increase the engine speed. Decreasing the tension will lower the engine speed. The point at which the pull of the spring equals the force of the air vane is called the “governed speed”.

Figure 1.18

The mechanical governor, fig.1.19, works in a similar manner except that instead of the force of the air blowing against the vane, we have the centrifugal force of flyball weights opposing the governor spring.

In either case, operation is the same. As the load on the engine increases, the engine will start to slow down. As soon as this happens, the centrifugal force of the flyball weights lessens. This allows the governor spring to pull the throttle open wider increasing the horsepower to compensate for the increased load and thus maintain the desired governed speed.

If the load on the engine lessens, the engine starts to speed up. This will increase the pressure of the centrifugal force and the spring will be stretched a little farther thus closing the throttle and reducing the engine power. A properly functioning governor will maintain this desired speed within fairly close limits.

Figure 1.19

In general, an engine that has good compression, carburetion, and ignition will operate efficiently. However, dirt or neglect can ruin an engine quickly. It should be the duty, therefore, of every salesman or repairman to instruct the customer in the proper operation and care of the engine so that he will obtain the long service life that is built into the engine at the factory.

AIR CLEANERS

The air entering the engine is important in engine performance and engine life. Power will decrease 3-1/2% for every feet above sea level.

Power will also decrease 1% for every 1- degrees Fahrenheit above the standard temperature of 60 degrees Fahrenheit. In addition the ambient temperature is important in the cooling of the engine. (Ambient temperature is the temperature of the air immediately surrounding the engine).

One of the reasons for engine wear is dust that gets into the engine. When you consider that one of these 3 HP engines operating at 3600 RPM used about 390 cubic feet of air an hour entering at the rate of about 24 miles an hour and that many such engines operate in very dusty conditions it is not hard to visualize the amount of dust and dirt that can enter an engine if it does not have an air cleaner or if the air cleaner is not functioning properly. If dirt gets past the air cleaner it enters the combustion chamber. Some may be blown out through the muffler but some may adhere to the cylinder where it creates ring wear or it may work down the walls into the crankcase where it causes wear on all the moving parts.

It is important to stress regular and proper maintenance of this important device.

Dirt that enters the engine through the breather also can wear out any engine. It is very important to see that the breather tube is in place on all engines.

Oil Foam No Spill Air Cleaners

For many years the oil bath air cleaner was considered the best, but Briggs & Stratton developed the Oil Foam “No Spill” Air Cleaner, Fig.2.1. This cleaner employs a polyurethane element. The important patented feature is that it is sealed. Other cleaners are made with a polyurethane element but some are merely blocks of material with no seals of any kind thus allowing the air and dirt to bypass the element. The Briggs & Stratton cleaner uses the edges of the element as gaskets so that the air must pass through the element.

Figure 2.1

There are two other important features of the “No Spill” cleaner. Oil will not spill if the engine is tilted. If the element becomes loaded with dirt, the air supply will be shut off so the engine will lose power or stop entirely. Then the element can be cleaned, re-oiled and reinstalled as good as new. The element must be re-oiled after cleaning.

A properly serviced air cleaner protects internal parts of engine from dust particles in the air. If air cleaner instructions are not carefully followed, dirt and dust which should be collected in cleaner, will be drawn into engine. It will become a part of oil fuel and is very detrimental to engine life; dirt in oil forms an abrasive mixture which wears moving parts, instead of protecting them.

No engine can stand up under the grinding action which takes place when this occurs. The air cleaner on every engine brought in for a check up or repair should be examined and serviced. If cleaner shows signs of neglect, show it to customer before cleaning, and instruct him on proper care to ensure long engine life.

Note: Air cleaner element and/or cartridge should be replace if damaged or restricted. Replace air cleaner gaskets and mounting gaskets that are worn or damaged to prevent dirt and dust entering engine through improper sealing. Straighten or replace bent mounting studs.

Air Cleaner Identification

Refer to Fig. 2.2 through 2.5 to determine type air cleaner being used and service procedures to use.

Cartridge Type

(with or without Oil Foam pre-cleaner or non-oiled pre-cleaner)

Removal and Installation:

1. Remove knob and cover
2. Remove foam pre-cleaner by sliding it off of paper cartridge.
3. Clean foam pre-filter, as described below.

a. Wash foam pre-cleaner in a low or non sudsing detergent and warm water solution.

NOTE : Do Not use petroleum solvents such as kerosene, to clean cartridge or pre-cleaner

b. Rinse thoroughly with flowing water from inside out until water is clear.

Fig. 2.2 - Dual Element Air Cleaner

c. Allow cartridge and pre-cleaner to stand and air dry thoroughly before using. DO NOT oil cartridge. DO NOT use pressurized air to clean or dry cartridge.

d. Saturate foam pre-cleaner in new engine oil. Squeeze to remove excess oil.

Reverse Flow Cartridge Air Cleaner, Vertical Crankshaft Removal and Installation

Figure 2.3

1. Remove air cleaner stud, cover screw, cover and gasket.

2. Remove plate screw, washer and plate.
3. Remove cartridge and clean air cleaner body carefully to prevent dirt from entering carburetor. Brush dirt from body through holes into duct.
4. Clean cartridge, by tapping gently on a flat surface.
5. Re-assemble air cleaner as shown in Fig. 2.4

Flat Cartridge, Vertical Crankshaft Removal and Installation

Figure 2.4

1. Loosen screw and tilt cover as illustrated is Fig. 2.5.
2. Carefully remove cartridge and foam pre-cleaner when so equipped.
3. Clean cartridge, by tapping gently on a flat surface. If very dirty clean as described on page 16-17 and pre-cleaner, as described on page 16-17.
4. Reassemble air cleaner as shown in Fig. 2.4
5. Install cartridge and foam pre-cleaner, when so equipped.
6. Then close cover ad fasten screw securely. Tabs in cover must be in slots of back plate.

Figure 2.5

Flat Cartridge, Horizontal Crankshaft
Removal and Installation

1. Loosen screws and remove cover, Fig. 2.6
2. Clean cartridge as described on page 16-17.
3. Clean dirt from inside of cover.
4. Reinstall cartridge in cover with mesh side out.

Figure 2.6

When to Clean

CARTRIDGE only, Clean every 25 hours or once a season, whichever comes first. More often in dusty conditions.
CARTRIDGE with dry pre-cleaner, pre-cleaner every 25 hours and cartridge every 100 hours. More often in dusty conditions.
OIL FOAM, every 25 hours. More often in dusty conditions.

If very dirty, replace cartridge or wash in a low or non-sudsing detergent and warm water solution.

Rinse thoroughly with flowing water from inside out until water is clear, all cartridges except REVERSE FLOW.

Rinse thoroughly with flowing water from inside out until water is clear, all cartridges except Reserve Flow.

Rinse thoroughly from outside in until water is clear, Reserve flow only.

Cartridge must be allowed to stand and air dry thoroughly before using.

Reassemble as described on previous pages, based on type of air cleaner.

❣ CAUTION: Petroleum solvents, such as kerosene, are not to be used to clean cartridge. They may cause deterioration of cartridge. They may cause deterioration of cartridge. DO NOT OIL CARTRIDGE. DO NOT USE PRESSURIZED AIR TO CLEAN OR DRY CARTRIDGE.

Clean and re-oil air cleaner element every 25 hours or at three month intervals under normal conditions. Capacity of “Oil-Foam” air cleaner is adequate for a full season’s use, without cleaning, in average home owner’s lawn mower service. (Clean every few hours under extremely dusty conditions.)

Principals Of Operation

Compression

The amount the engine will compress the fuel mixture depends on how small a space the mixture is squeezed into. Notice in Fig. 3.1.

The piston in A has traveled down 6 in. from the top of the cylinder. This is the intake stroke. In B the piston, on the compression stroke, has traveled up to within 1 in. of the cylinder top. It is obvious that 6 in. of cylinder volume have been squeezed into 1 in. of cylinder volume. This gives a ratio of 6 to 1. This is termed the Compression ratio.

A B

3.1 Compression ratio

Valves have to seal well enough to withstand pressures of 100 to 200 pounds per square inch. Under full load, the exhaust valve is exposed to temperatures high enough to cause it to operate at a red heat. The temperature of the exhaust valve under these conditions may be 1200Ec or more. The intake valve is cooled by the incoming mixture. The exhaust valve is subjected to high temperature exhaust gases passing over it on their way out of the cylinder. It is, therefore, very difficult to cool the head of the exhaust valve. The cylinder head, the cylinder, and the top of

the piston is exposed to this same heat, but it is cooled by heat radiating to the engine block which is cooled by air from the fly wheel fan and oil from the crankcase. Very special steel is required in the exhaust valve to enable it to withstand the corrosive action of the high temperature exhaust gases.

The general subject of compression is a familiar one to most mechanics. It has been discussed in detail by valve manufacturers, ring manufacturers, piston manufacturers, and by makers of valve grinding equipment. The home mechanics, or handyman, thinks nothing of getting out his grinding compound, lapping in the valves and putting a new set of rings on the piston - all without knowledge of proper fit or tolerance. Whether he does the job right or not, he thinks it is easy. And, it is easy. There is nothing difficult or mysterious about compression, and the nice part is that a good job that will create lasting customer satisfaction is as easy to do as a poor job.

We must keep in mind, however, that the rules for small air-cooled, single cylinder engines. Do not always hold true on liquid-cooled, multi-cylinder engines for example:

The operating temperature of a liquid-cooled engine is quite constant. The operating temperature of an air cooled engine, however, may vary greatly with changes in air temperature, the load, and the speed. This necessities differences in tolerances and clearances of parts like pistons, which must be fitted to the small engines established clearances. These can differ from those used in most automotive engines.

The advantages of an air-cooled engine are many. There is no need for a complicated cooling

system. The engine is lighter in weight and occupies less space than its liquid-cooled counterpart, and is comparatively easy to repair.

Before we get into the mechanics of the subject, let us clarify some of the terms in common use. On single cylinder engines we think of good compression, not in terms of pounds or pressure per square inch, but in terms of horsepower output. If the engine produces the power for which it was designed, we believe the compression must be good. It is extremely difficult to make an accurate compression test on a small, one cylinder engine without expensive machinery. The reasons for this are the lack of a starter to crank the engine at a constant speed and the small displacement of the cylinder. Therefore, we do not publish any compression pressure figures. As a simple compression test, give the flywheel a quick spin counterclockwise. If the flywheel rebounds on the compression stoke, the compression is at least good enough to start the engine.

We talk about “compression” stroke and “power stroke”. What are they? The four-stroke cycle engine or as it commonly called, a four cycle engine operates on the same principle as an automobile engine. The crankshaft makes two complete revolutions to each power stroke of the piston.

Figure 3.2 Figure 3.3

The first stroke of the for stroke engine is the intake stroke with the intake valve open the piston is drawn down the cylinder a low pressure area is created in the combustion chamber. This low pressure area is filled with the gas air mixture created in the carburetor. The engine then begins the compression stroke. As the piston reaches the top of the compression stroke, the mixture of air and fuel is broken into tiny particles, and heated up. When ignited, it will explode with great force.

This is the time to explode the mixture. A spark is provided inside the combustion chamber by means of a spark plug. The spark produced at the plug is formed by the ignition system. This will be discussed later. Just image that a hot spark has been provided in the fuel mixture. The mixture will explode, and in turn force the piston down through the cylinder. This gives the crankshaft a quick and forceful push.

Both valves must be kept closed during the compression stroke or the pressure of the burning fuel will squirt out the valve ports. See Fig. 3.3.

Remember: The power stroke starts with the piston at the top of the cylinder, both valves closed and stops with the piston at the bottom of the cylinder. This requires another one-half turn of the crankshaft. Stroke No. 4 - The Exhaust Stroke - Fig. 3.5.

When the piston reaches the bottom of the power stroke the exhaust valve opens. The spinning crankshaft forces the piston up through the cylinder blowing burned gases out of the cylinder blowing burned gases out of the cylinder. See Fig. 3.5.

Remember: The exhaust stroke starts with the piston at the bottom of the cylinder, exhaust valve open, intake closed, and stops with the piston at the top of the cylinder. This requires one more one-half turn of the crankshaft.

Completed Cycle

Figure 3.4

If you will count the number of half turns in the intake, compression, firing and exhaust strokes, you will find you have four one-half turns. This gives two complete turns, (called revolutions of the crankshaft.

While the crankshaft is turning around twice, it is receiving power only during one-half turn, or one-fourth of the time.

Figure 3.5

Remember again that the single cylinder four stroke engine is an engine with two (2) valves as compared to the customary 12 or 16 valves in an automotive engine. The fewer the valves, the more important they become.

Fig. 3.6 - Relative Importance of Valves

In a one cylinder engine, one bad valve can cause a great drop in horsepower or cause the engine to stop entirely. In a multi-cylinder engine, one valve may fail and only 1/6th or 1/8th of the power is affected as the bad cylinder may be motorized by the other good cylinders. Hence, good valve condition is even more important in 1 cylinder engines than it is in multi-cylinder engines.

Now if the valves and seats are so important, how do we do a good valve job on a four cycle engine?

The first requirement is good equipment. A valve refacer and valve seat grinders are necessary. If you do not have them, arrangement should be made with your local small engine dealer.

After the valves are removed, they should be thoroughly cleaned on a wire brush wheel to remove all carbon deposits. Sometimes it is easier to polish carbon than to remove it, but it must come off. Also, remove carbon from the valve guides. When the valves are clean, they should be visually inspected.

Figure 3.7

As mentioned above, when a valve becomes defective in a multi-cylinder engine, the bad cylinder is motorized by the other cylinders. This may cause serious damage to the valve and seat. Single cylinder engine valves are seldom subjected to the extremes of abuse that automotive valves are. While valves may burn to some extent, it is very seldom that a valve seat or face is very badly burned. Dished or necked valves are more commonly found on car engines.

Valve seat burning is usually caused by an accumulative of carbon or fuel lead either on the valve stem or on the valve face, or from insufficient tappet clearance. These deposits on the valve stem or on the face will hold the valve open, allowing the hot flames of the burning fuel to eat away the valve face and seat. A dished valve is one that has a sunken head. This is caused by operating at too high a temperature with too strong a spring, or the head can be eroded away by highly leaded fuels. A necked valve is one that has the stem directly beneath the head eaten away badly by heat or where the stem has been stretched.

Valve sticking is caused by fuel lead, gum or varnish forming on the valve stem and in the valve guide. We believe that the most of the deposits formed are caused by carbon fuel lead, or gum. Since the amount of lead in different fuels varies, the rate of deposit build up naturally will vary. When an exhaust valve no longer closes properly, due to excess deposits, the hot gases escaping from the combustion chamber heat up the valve stem and guide excessively. This causes the oil on the valve stem to oxidize into varnish which holds the valve partially open and causes burning. Intake valve sticking may be caused by the use of fuels having an excessively high gum content. Fuels that are stored for too long a period may contain high amount of gum. If burning occurs in a rather limited area on the valve face, it indicates that something may have caused the valve to tip.

This could be due to a bent valve stem or a deposit on one side of the valve or stem.

Such a condition would leave an opening for the passage of hot exhaust gases which could burn the valve so badly that it would not be refaced. These valves must be discarded.

The important parts of a valve are the head, the margin, face and stem. They make contact with the seat and the valve guide in the cylinder. The margin is the edge of the valve head. As general rule, the valve should be discarded when the margin becomes less than one-half of the original thickness.

The margin on most four stroke cycle valves is 1/32 of an inch, so that when it becomes less than 1/64 of an inch the valve should be discarded. Remember, this is after all pit marks and burn marks have been removed from the valve face. If the valve is bent, the face will be ground unevenly, and if the margin becomes too thin on one side the valve should also be discarded. A valve with too thin a margin will not be able to withstand the heat and will quickly crack and burn. After facing the valves and the valve seats to a 35 or 45 degree angle, place a little fine grinding
compound on the valve face, and very lightly lap the valve to the seat.

Figure 3.9

Use of fine grinding compound removes any grinding marks and gives a clear picture of the valve seat width. Be sure to remove all grinding compound from seat and valve.

The valve seat width is usable up to 5/64 of an inch, but a new seat should be between 3/64 and 1/16 of an inch, and it should be in the center of the valve face. After the valve seat and faces are ground, the valve should be installed in the guide, the cam gear turned

Figure 3.10

to the proper position, and the tappet clearance checked. Refer to Repair instructions for tappet clearance. Usually the clearance will be too small, and the end of the valve stem will have to be ground off to obtain the proper clearance.

Care should be taken not to overheat the end of the valve stem while this grinding is taking place; be sure the end is square with the stem. It is recommended that the valve springs and retainers be assembled immediately after setting the tappet clearance to prevent chances of dirt getting under the valve seat.

Principals of Operation
2 Stroke Cycle

Two Stroke Cycle Design Variations

Cross Scavenge Design - The fuel air mixture enters the combustion chamber on one side of the cylinder. The domed piston head directs the mixture to the top of the combustion chamber and assists in sliding the exhaust gases out through the exhaust ports. Fig. 3.11.

Reed Valve - is a flap or flutter valve that is activated by crankcase pressure. (Fig. 3.11.) A reduction in crankcase pressure opens the valve allowing the fuel air and oil mixture to enter the crankcase. Increased crankcase pressure closes the valve, prohibiting escape of the fuel-air and oil mixture through the carburetor.

Figure 3.11

Figure 3.12 illustrates the loop scavenge design and again uses the vacuum-pressure activated reed valve. Here the ports are located on three sides of the cylinder; the intake ports are on two sides opposite each other and the exhaust ports are illustrated by the three holes just above the head of the piston.

The flat piston is used in this design. As the mixture shoots into the combustion chamber through the two sets of intake ports it collides and is directed to the top of the combustion chamber looping when it strikes the cylinder head, thus forcing all spent gases out through the open exhaust ports before it.

Figure 3.12

Figure 3.13 also shows the loop scavenge design, but the reed valve has been eliminated. The carburetor has been moved from the lower crankcase end to the cylinder. Along with the intake and exhaust ports a 3rd port has been added. The 3rd port forms the passageway from the carburetor to the crankcase and is opened and closed by the piston skirt as the piston moves back and forth in the cylinder.

The carburetor appears to block off the path from the crankcase to the intake ports, however, these gases pass around the carburetor and 3rd port.

Figure 1.13

Figure 3.14 is essentially the same loop scavenge, 3rd port design as show in Figure 3.13, the only difference is the two small reed valves are located on the adapter cover from the carburetor to the 3rd port. These reed valves open early by vacuum created as the piston starts to rise. An extra amount of fuel-air mixture passes through these reed valves before the piston skirt opens the 3rd port. This extra charge of fuel-air mixture increases engine horsepower.

Figure 3.14

TERMS USED IN 2-CYCLE THEORY

Exhaust or Scavenge Phase - The phase resulting from the burning of air and fuel. The burned gases must be cleared out of the combustion chamber and replaced by a fresh charge of fuel-air mixture. The exhaust passes out through the exhaust ports into the outside air.

Exhaust Ports - Allow the burned gases to pass out of the combustion chamber.
Ports - Small openings in the cylinder allowing gases to pass into and out of the combustion chamber. The ports are open or closed by the upward and downward movement of the piston.

Figure 3.15

Third Ports - A third port, is for entry of the fuel-air and oil mixture to the crankcase. From the crankcase the fuel-air mixture enters the combustion chamber through the intake ports and the oil lubricates the moving parts. The third port is controlled by the piston skirt. See Figure 3-4.

Lubrication - Tecumseh 2-cycle engines utilize an oil mist lubrication. The correct quantity of oil is mixed with the fuel and enters the crankcase through the carburetor with the fuel-air mixture.

The oil then clings to the moving parts and lubricates the bearing surfaces.

C. Third Port Operation

The piston moves up toward the top of the combustion chamber. All ports are closed creating a reduced pressure within the crankcase and a compressed fuel-air mixture within the combustion chamber.

At a point BEFORE the piston reaches TOP DEAD CENTER (TDC) the spark plug ignites the fuel air mixture. The third port opens allowing the fuel and air mixture to enter the crankcase to equalize the reduced pressure, Fig. 3.16.

As the expanding gases from combustion force the piston toward the bottom of the cylinder, crankcase pressure increases, Fig. 3.17.

Figure 3.16

In figure 3.18 the continued downward movement of the piston uncovers the exhaust ports and intake ports. The pressurized fuel air mixture within the crankcase flows through the open intake ports and the burned gases are forced out through the exhaust ports in figure 3.19. The sequence then repeats itself.

Figure 3.17

Figure 3.18

Figure 3.19

Four stroke-Cycle Engine vs **Two-Stroke Cycle Engine**

Intake Stroke	Compression Stroke	Power Stroke	Exhaust Stroke

Figure 3.20

Figure 3.20 illustrates the four -stroke-cycle principle. Intake - As piston moves down or toward the crankcase, intake valve opens and partial vacuum is created in cylinder. Vaporized fuel and air mixture is forced into cylinder by atmospheric pressure.

Compression - Intake valve closes. As crankshaft rotates, piston moves up and compresses the fuel-air mixture.

Power - Ignition system fires spark plug to ignite fuel mixture just before piston reaches top of its travel. Expanding gases which result from burning of fuel, force piston down to turn crankshaft. Exhaust - After fuel charge is burned, exhaust valve opens. Burned gases are forced out of cylinder by upward movement of piston.

This series of events, called a four-stroke-cycle, is then repeated. A four-stroke-cycle engine fires on every fourth stroke. A cycle requires two turns of the crankshaft.

Two Stroke Cycle Engine

3.21 shows the two-stroke-cycle principle.

In left hand view piston is traveling upward. It is compressing the fuel charge and drawing fuel mix into crankcase through the reed valve. The fuel vapor contains suspended droplets of oil that lubricate surfaces of moving parts.

In right hand view mixture has fired and piston is traveling down. It has uncovered intake and exhaust

Figure 3.21

ports allowing burned gases to escape and fresh charge to enter. Fuel mixture flows through intake port because piston, while traveling down, compressed mixture in crankcase. In two strokes, requiring one revolution, engine has performed all the necessary functions to enable it to receive a power stroke for every crank revolution.

Where is the Low Pressure Area?

If the piston is at the top of the cylinder, with both valves closed, and turn the crankshaft, the piston will be drawn down into the cylinder. This forms a strong low pressure area in the cylinder. If you now open the intake valve, the air will rush into the cylinder. This is called the Intake stroke.

Stroke No. 1 - The Intake Stroke

The first stroke in the engine is the intake. Instead of opening the intake valve after you have drawn the piston down, you will find it better to open the intake valve as the piston starts down. This allows the air to draw fuel in all the time the piston is moving down. If you wait until the piston is down, to open it, the piston will be starting up before the cylinder can be filled with air. See Fig. 3.22.

Figure 3.22

Remember: The intake stroke starts with the piston at the top of the cylinder, intake valve open, exhaust valve closed, and stops with the piston at the bottom of its travel. This requires one-half turn of the crankshaft.

Stroke No. 2 - The Compression Stroke

You have discovered that the smaller the particles of gasoline, mixed in air, the more powerful the explosion.

As the crankshaft continues to move, the piston is forced up through the cylinder. If you keep both valves closed, the fuel mixture will be squeezed, or compressed, as the piston reaches the top. This is called the compression stroke. See Figure 3.23.

Figure 3.23

The compression stroke serves several purposes. First it tends to break up the fuel into even smaller particles. This happens due to the sudden swirling and churning of the mixture as it is compressed.

When engine fuel mixture is subjected to a sudden sharp compression force, its temperature rises. This increase in temperature makes the mixture easier to ignite, and causes it to explode with greater force.

As the piston reaches the top of its travel on the compression stroke, it has returned to the proper position to be pushed back down by the explosion.

Remember: The compression stroke starts with the piston at the bottom of the cylinder, both valves closed, and stops with the piston at the top of the cylinder. This requires an additional one-half turn of the crankshaft.

Gas and Oil

The standard fuel for industrial gasoline engines is of course gasoline. This is usually the "regular" gasoline applied for automobiles. It may include small quantity of tetraethyl of lead, a poisonous compound that reduces tendency to knock, and/or other chemicals to improve performance, together with a dye to give warning of any poison, or to identify make or quality.

This engine will operate satisfactorily on any gasoline intended for automotive use. A minimum of 87 octane is recommended. **DO NOT MIX OIL WITH GASOLINE**. When in doubt about your engine always refer to the owners manual.

Use Clean, fresh, lead-free gasoline. Purchase fuel in quantity that can be used within 30 days. This will assure fuel freshness and volatility tailored to the season. Leaded gasoline may be used if lead-free is not available. Use of lead-free gasoline results in fewer combustion deposits and longer valve life.

NOTE: Many Manufactures **DO NOT** recommend the use of gasoline which contains alcohol, such as gasohol. However, if gasoline with alcohol is used, it **MUST NOT** contain more than 10 percent Ethanol and MUST be removed from the engine during storage. **DO NOT** use gasoline containing Methanol.

Numerous service and owners manuals recommend the use of a high quality detergent oil classified "For Service SF, SE, SD, SC" 30 weight. Detergent oils keep the engine cleaner and retard the formation of gum and varnish deposits. No special additives should be used with recommended oils.
Gasoline is classified by octane rating. Octane is an excellent fuel in anti-knock characteristics, and is given a 100% rating. Heptane is a poor anti-knock fuel and is given a 0% rating. The octane number of a gasoline is the octane percentage in a mixture of octane and heptane which it matches in antiknock valve.

Commercial range now is approximately 5 to 90 for regular gasoline with additives, 91 to 95 for premium quality, and 100 to 115 for aviation gasoline.

Fuel Difficulties

Poor fuel supply is responsible for a large part of the difficulties found in starting and running engines. Causes include dirty and clogged lines and filters, water, leaks, vapor lock, and defects in pumps.

1) Dirt gets in the fuel while it is being carried in cans. It blows into the tank through the cap breather hole, and it is formed in the tank by corrosion. Some of it settles to the bottom of the tank without causing trouble, but most of it moves into the lines eventually. It is apt to plug a line at an elbow or low spot, and it will accumulate in filters until they are plugged.

Most trouble with dirt, and some trouble with water, can be avoided by careful handling of fuel in clean, covered containers. Frequent draining of sumps in the bottom of the fuel tank and the filters, and changing filter elements, will prevent trouble with that you do get.

Occasionally you will find a fuel tank that corrodes badly and causes constant trouble with its dirt in the lines. This is usually the result of a manufacturer's mistake in selecting contaminated materials, but by the time it shows up it is too late to do anything about it. A tank that is a persistent trouble maker should be replaced.

2) Condensation. Warm air can carry much more water vapor than cold air. A cold object in contact with warm damp air will become covered with a dew of condensed moisture that easily becomes heavy enough to drip. This can be seen on a glass containing an iced drink, and happens in the same manner on surfaces inside and outside a piece of equipment. Very small differences in temperature will cause condensation from air that is not free to circulate.

Night cooling that puts dew on the grass may also wet the inside of the tank above the fuel level. Even more severe condensation may be caused by leaving the machine under a tarpaulin without ventilation, as the tarp will hold moisture in during the heat of the day, and allow it to chill and condense at night.

3) Water. If condensation is heavy, some of it will run down into the fuel and accumulate in the bottom, along with water that may come in the fuel itself. This may fill up the sump provided for it and spill into the fuel line. A little may go through the engine harmlessly, or cause slight missing and hard starting. Or it may be stopped by a filter and accumulate in its bowl or sump, where it will eventually build up high enough to block the flow of fuel.

Such water may freeze in the fuel lines in the winter, even when the machine is running, so as to block them and require a major thawing operation. Metal fuel lines will usually survive one freezing, but a second or third will split them.

Trouble with condensation maybe largely avoided by keeping the tank full so that water bearing air cannot stand in it. That is, fill it at the end of the shift. This also applies to cans and tanks in which spare fuel is kept. It is also a good plan to throw away the last cup of fuel in a can, and rinse an empty can with fuel before filling it.

It is often not practical to keep tanks full, and water might get incidentally from other sources. It can be disposed of painlessly by adding a cup or two of antifreeze alcohol or some special compounds sold for the purpose. The chemical serves the dual purpose of preventing the water from freezing, and of lowering its surface tension so that it will mix with the fuel and go through the filters and jets or injectors harmlessly. Results are almost magical, but the treatment must be given before freezing, not later.

4) Vapor Lock. Vapor lock, also known as air lock, caused by air or vaporized fuel (usually

gasoline) that slows or stops the movement of fuel through the lines. It is usually the result of the inability to fuel pumps to pump air. Even a small bubble of air in some types of pump will cause it to stop pumping fluid, sometimes for a few seconds, sometimes until the air is bled out. Air may feed in a little faster than the pump can handle it, building up to block it.
A pump may be able to handle some air at normal operating speed, but be unable to pass it at idling or starter speed. The result is that an engine with a small leak in the suction line may be difficult to start, but run all right once it starts firing.

Vapor lock in a gasoline engine is most likely to occur in hot weather, and can often be cured by putting insulation between the fuel line and the exhaust manifolds.

Most engines, gasoline or diesel, have at least one section of flexible hose before the pumps as the movement of the engine on its supports would break a metal tube very quickly. The flexible hose might last six months or three years, but sooner or later it will deteriorate. It is your job to catch and replace it before it stops the machine on the job.

If a flexible hose shows any damp spill from leaking fuel, is swollen, or feels flabby when pinched between two fingers, it should be replaced. Try to stop a few flexible hoses, with some adapter and replacement fittings, so you can do the small job ahead of time, and avoid emergency calls to the field.

Air leaks can often be found by clearing and drying the outside of the fuel system, then watching for leakage. A hole that lets fuel out may let air in.

Engine Care

Everything you should know about motor oil ... and then some

You probably already know that motor oil is the lifeblood of an engine and that many experts recommend changing it every 5000 kilometers or so. That’s the easy part. What confuses many people is how the various types of oil differ, what type is best for their car, and just what all that stuff on the label really means.

Anatomy of an oil

While browsing among the shelves in your local auto parts store, you'll find three main motor-oil types: conventional petroleum or mineral-based, synthetic, and a blend of these two. Conventional oil, of course, is refined from the crude oil pumped out of the ground. The crude is refined through a process of building an evaporative collection called fractional heavier elements of the crude oil are boiled off and collected. This is how gasoline, diesel fuel, and other petroleum products as well as engine oil are distilled out of the crude. The oil is further processed into different weights and unwanted elements are removed, resulting in what are called "base stocks".

Synthetic oils are developed chemically, as opposed to being refined from crude oil. While the first synthetic oil is said to have been processed from methane gas by German scientists during World War II, major elements in todays synthetics are more-advanced compounds known as esters and polyalphaolefin (PAO), which was pioneered by Mobil in the early '70s. Synthetics generally cost more than petroleum based products due to their more complex refinishing process, but they provide a wider performance envelope with distinct advantages in several areas. Synthetics, for instance, flow well at low temperatures, making them excellent for winter use. They also have exceptional thermal stability, which makes them a good choice for high-load, high-heat summer conditions. Synthetics are less volatile, which reduces oil consumption and makes them more forgiving of abuse and less susceptible to the harmful effects of oxidation. Some synthetic-oil suppliers also tout longer change intervals, however, vehicle manufacturers still recommend adhering to the regular oil-change schedule because while the synthetic base stock may hold up longer, the normal buildup of internal deposits and the breakdown of additives continue to occur.

A third type of motor oil is a petroleum-synthetic blend, which combines some of the high-performance attributes of synthetics with the more modest price of conventional oils. A typical blend might contain a ratio of about 80% petroleum base stock to 20 percent synthetic.

If basic lubrication were the only duty engine oil performed, these base stocks might suffice, but today's oil is expected to do much more than simply lubricate. It also protects the engine's internals from corrosion due to moisture or acid, provides extra sealing between piston rings and cylinder walls, helps cool interior parts, and helps keep the engine clean by holding contaminants and deposits in suspension until they reach the filter or are drained out.

To prepare these stocks for use in real-world engines, various chemical additives are implemented to fight motor oil's natural performance enemies:

- Sludge, carbon, and other deposits can build up on internal surfaces, impairing the oil flow and effectiveness , detergents and dispersants are added to hold these elements in suspension so they can be removed easily.
- High heat causes oil to thin out, while cold temperatures cause it to thicken; viscosity-index helps minimize these changes.
- Friction modifiers help form a protective film on engine parts, reducing wear and improving fuel efficiency.
- Anti-foaming agents reduce foaming, which can compromise an oil's ability to lubricate by blocking the liquid oil from reaching metal surfaces.

- High heat such as that generated in the combustion chamber, causes oil to react with oxygen, which in turn makes it thicken and can create sludge, varnish, and acids. Oxidation, inhibitors control this process.
- Acids and moisture due to condensation can corrode internal engine surfaces so alkaline compounds and rust inhibitors are added to fight these problems.

An oil's "pour point" is its so-called "freezing" point: the temperature at which an oil solidifies into plastic making it unusable as a lubricant. Pour-point depressants lower this point, helping to keep the oil flowing at very low temperatures.

Time for a change?

The interval at which oil should be changed in any given vehicle is dependent upon a number of varying factors which as driving style, traffic conditions, engine load and temperature, and oil consumption. The most accurate way to determine the proper interval for a particular car and driver combination is through a series of oil analysis tests, as is done in large-fleet situations. That, however, can be more expensive than the oil itself. To keep things simple, most auto manufacturers recommend changing the oil about every 12,000 kilometers under normal driving conditions, or about every 5,000 kilometers if the vehicle is driven under severe conditions. Check your owner's manual. You may be surprised to find that so-called "severe" conditions are fairly normal for many of us: lots of stop and go traffic, many successive short trips during which the engine doesn't have much time to achieve and maintain its normal operating temperature, extended high-speed highway driving, running the engine under a heavy load such as when towing, or driving in dusty conditions.

Decoding the Label

Viscosity index: Simply put, this is a measure of an oil's thickness, or how easily it flows. The measuring system is based on standards established by the Society of Automotive Engineers (SAE) and is often referred to as the SAE rating. The higher the number, the thicker or heavier the oil and the slower it flows. The normal range runs from a "5-weight" fluid (5W), which is relatively thin and easy-flowing, to "50-weight", which is relatively thick and slower-flowing. All oil grades are tested for proper viscosity at 100 degrees Celsius, which is a normal engine-operating temperature. Grades containing a "W" as part of the index (5W, 10W, etc.) also are tested at zero degrees Fahrenheit to simulate cold start conditions for use in winter temperatures.

Thicker or high viscosity oils provide better protection and lubrication but can have a hard time circulating through the engine in cold ambient temperatures, creating hard-starting problems and a longer period of inefficient lubrication. Thinner or low-viscosity grades flow more easily but don't provide as thick a cushion of oil.

The best solution is to use multi grade oils (such as 5W-30, 15W-40, etc.), which remain thin at low temperatures to help circulation and ease engine starting, but thicken at higher temperatures to provide optimum protection. This reversal of common logistics accomplished using special organic polymer additives, which expand with heat. These polymers are added to a low-viscosity base stock (such as 10W oil for a 10W-40 final product). At low temperatures, the polymers

contract and don't affect the base stock's viscosity. As the temperature rises, the polymers expand and become more soluble, making the oil thicker and raising its viscosity.

While oil grade is best for you? If you decide to go with a monograde oil, the following guide can help you decide which is optimal for the temperatures you expect to be driving in:

- 5W: For extreme winter conditions, where temperatures are frequently well below zero.
- 10W: For use in a temperature range from about zero to 10 C.
- 20W: For use in temperatures that rarely drop below -5 C.
- 30: A good general-use weight for moderate and summer temperatures
- 40: For summer temperatures only, and for when the engine is working under heavy loads.
- 50: For long-distance high-speed driving

Star-burst Certification Symbol:
This certification program (called the engine Oil Licensing and Certification System) was initiated jointly on August 1, 1993, by the American Petroleum Institute (API) and the American Automobile Manufacturers Association (AAMA), and identifies motor oils that meet or exceed all U.S. and Japanese automaker performance specifications. From '94 models on, Chrysler, Ford, and GM recommend use of engine oils meeting these specifications for all their vehicles. This star-burst mark is used as an easy way for vehicle owners to identify oils that meet these standards.

Some manufacturers don't recommend multi grade oils with wide viscosity ranges, such as 10W-40 or 10W-50; therefore, you won't find the star-burst symbol on them. This is because they have a higher percentage of polymer additives than a narrower multi grade oil. Polymers can begin to break down after a couple of thousand miles. This causes the oil to become thinner at higher temperatures, which increases oxidation and the formation of sludge. A higher percentage of polymers increases this effect. However, if a wide-viscosity - range oil is recommended by your vehicle's manufacturer, you can feel comfortable about using it.

API service category:

This is identified by two letter designations developed by the American Petroleum Institute and is intended by define the minimum quality of oil suitable for the engine. If the first letter is "S" this indicates the oil was developed for gasoline engines; "C" indicates oils formulated for diesel engines. The second letter indicates the oil's performance level in a variety of tests; the higher the letter, the better the performance. "SH" oils, for instance, offer better overall engine protection than an "SE" or "SF" category for gasoline engines, just as "CD" provides better performance than "CC" for diesel engines. Check your owner's manual for the minimum service category recommended by your vehicle's manufacturer. Although a lower grade may be specified for older cars, it's okay — and preferable — to use a higher service category of oil if you can. Currently, the API's highest ratings for passenger cars and light trucks are SH for gasoline and CD for diesel.

Energy conservation:

An oil exhibiting this mark meets standards for reduced operating friction, which provides better engine efficiency and fuel economy. For an oil to earn an "Energy Conserving" label, it must

provide a fuel economy increase of at least 1.5 percent over a standard reference SAE 30 engine oil. Those marked “Energy Conserving 11" must improve fuel economy by 2.7 percent or more over the standard reference oil.

CCMC requirements:

The Committee of Common Market Automobile Constructors sets performance requirements for European vehicle manufacturers; the standards are considered the most stringent in the world. An oil that meets these guidelines usually will state so on the label.

- If you add a new quart of oil to your car’s engine on a regular basis, don’t assume that this takes the place of changing the oil, since draining is still needed to remove contaminants and replenish the additive packages.

Tips for Changing Oil

Changing your vehicle’s oil is a simple and inexpensive procedure and helps keep you in touch with the engine’s health. Prior to doing the job, check your owner’s manual and purchase the right quantity of oil, making sure it has the recommended SAW viscosity rating for the temperature range you expect to be driving in, and the right API quality rating.

- Warm the engine to its normal operating temperature; warm oil drains more rapidly and will be holding more of the contaminants in suspension.
- Position a drain pan under the drainplug. Carefully remove the plug, avoiding contact with the hot oil, and allow the oil to drain into the pan. It isn’t critical to get every last drip out, since some oil remains in the engine passages and oil pump anyway.
- While the oil is draining, examine the oil plug gasket. If there’s any evidence of damage, replace it to avoid a possible leak.
- When the oil flow has dwindled to a slow drip, reinstall the drainplug and be sure to tighten it. This may seem obvious, but almost every do-it-yourselfer has at least one messy story of pouring new oil into the engine without having reinstalled the plug.
- Observe the oil’s color. Typical used oil is black. If it has a milky appearance, coolant may be leaking into the oil passages, and the problem should be fixed as soon as possible. When the oil is cool enough to touch, feel the bottom of the pan (wear latex gloves) for any metal bits, which could indicate internal engine damage.

If the oil filter is to be replaced, do it now. Reposition the drain pan under the oil filter. Next Unscrew the filter from its mount - using a filter wrench, if necessary - and pour the oil into the drain pan. Clean and check the filter mating surface on the engine to be sure there’s no damage that could cause a leak. Prior to installing the new filter, apply a thin film of fresh oil to its rubber gasket.

(Spreading a thin coat of fresh engine oil onto the rubber gasket of the new filter will help it seal snugly against the engine mounting surface)

If possible, it's also a good idea to pour fresh oil into the new filter to reduce the amount of time the engine is running without full oil pressure at initial start-up. Depending on the filter's mounting position, this may not be practical, because much of the oil could spill out. Screw on the new filter until the seal contacts the engine surface, then turn it an additional one-half three-quarters of a turn.

- Refill the engine with the proper amount of fuel.
- Restart the engine and allow it to idle for about a half-minute to let the oil pressure build. then check the oil level with the dipstick to be sure the level is correct.
- Finally, check under the engine for any oil leaks.

Excessive Oil Consumption?

- It isn't unusual for an engine in good operating condition to require a fresh quart of oil every month or so. If you're concerned about excessive oil consumption, there are a few checks you can make to locate any abnormalities.
- To detect an external leak, spread newspaper or a sheet under the car while it's parked overnight. If spots are evident the next morning, their location will help you pinpoint the leaks origin. Also check for leaks with the engine running, as sometimes the oil will leak only when under pressure.
- If there's excessive seepage past piston rings or valve stems, it's often evident by black or blue-gray smoke coming from the exhaust pipe, especially during acceleration. You might also see smoke during deceleration if the valve guides are bad. Have a compression test done on the engine to check for proper sealing. If this is the problem, it could entail a hefty repair bill.
- A low-viscosity (thin) oil flows more easily than a thick one, and therefore can more easily leak through faulty gaskets or other gaps. Changing to higher viscosity oil could help alleviate this problem, as long as it's still appropriate for the temperature conditions you'll be driving in.

Many people decide to treat the symptoms rather than the cause (at least temporarily) by adding an oil treatment product such as those made by STP, Restore, and others.

Small Engine Ignition System

Spark Plugs

The spark plug ignites the fuel-air mixture in the engine cylinder.

We have learned that there is no current flow in an open circuit, in most cases this is true. However, if the opening in the circuit is small and a high voltage is present, the high voltage will force the current to jump the small gap, thus completing the circuit. This is the basic principle of a spark plug.

Operation of spark plugs

The spark plug has two conductors called electrodes. One is connected to the high voltage power source by a high-tension cable and the other is grounded to the engine. Electrodes are separated by a small opening called the gap.

Figure 5.1

The high voltage surge from the coil flows thorough the cable to the center spark plug electrode and down the electrode. Then the current jumps the gap to the other electrode and returns to ground (Fig. 5.1.

When current jumps the gap, a spark is created to ignite the fuel-air mixture in the engine's cylinder.
Although the spark plug has no moving parts, each part is important (Fig. 5.1).

Outer Shell

Each spark plug has a steel shell. The top of the shell is hexagon shaped so a wrench can fit. The lower part of the shell is threaded so it can screw into the cylinder head. The grounded electrode extends out from the lower threaded part of the shell. The spark plug may have a gasket to help seal it to the engine cylinder head or the seat may be tapered to seal the spark plug.

The distance from the flange to the end of the spark plug threads is called the reach. The reach of a spark plug is very important. A spark plug with too long a reach will extend too far into the combustion chamber. The spark plug will run hotter, and may be hit by a piston. A spark plug with too short a reach will run cold and cause misfiring due to fouled electrodes. More on this

after.
The threaded diameter may vary according to the size of the spark plug hole in the cylinder head. The engine technical manual will give you the exact spark plug specifications for the engine.

Spark Plug Insulator

The insulator is mounted in the outer shell. The insulator is usually made of white ceramic or porcelain.

The insulator is held in position and shielded from the outer shell by a gasket and sealing compound.
The insulator holds the center electrode and insulates it so current will only flow through the electrode. It must also withstand extreme temperature changes and vibration.

Spark Plug Electrodes

The electrodes are made of a metal alloy designed to withstand constant burning and erosion.

The center electrode extends through the insulator. One end is connected to a stud screwed into the top of the insulator. The other end extends through the Lower cone of the insulator. The electrode is held in position by sealing compound.

The grounded electrode is part of the outer shell. It is bent so the end is directly beneath the center electrode.

The gap between the two electrodes is a prime factor in a spark plugs operation. This gap must be set to the exact engine specifications in the technical manual.

- If the gap is too small, the spark will be weak and fouling or misfiring may result.

- Too wide a gap may work fine at high speeds, but will misfire at low speeds.

- The surfaces of the two electrodes should be parallel and have squared corners.

HEAT RANGE OF SPARK PLUGS

The heat range of a spark plug is as important as the gap setting. In fact, the heat ranges of spark plugs are used to classify them.

The term heat range means the spark plug's ability to transfer heat at the firing tip to the cooling systems of the engine. The engine (Fig. 5.2). Heat transfer is governed by the distance the heat must travel.

Figure 5.2

Heat at the end of a spark plug with a long insulator cone has farther to travel to get to the cooler engine cylinder head than heat at the firing tip of a short insulator plug. So the short insulator plug runs cooler than the long insulator plug (Fig. 5.3).

Generally, an engine which operates at high speed or under heavy loads will run hotter and require a spark plug with a short insulator cone so the heat will transfer faster. A plug with a long insulator cone is used in an engine that operates at a lower speed. The engine's technical manual will tell you which spark plug to use.

Figure 5.3 - Hot & Cold Spark Plugs

Special Types of Spark Plugs

There are several kinds of spark plugs that are unique.

Resistor Spark Plugs

These spark plugs (Fig. 5.4) have a resistor between the terminal and center electrode to reduce radio and television interference by the ignition circuit.

Surface Gap Spark Plugs

Surface gap spark plugs eliminate the problem of grounded electrodes. The spark jumps from the center electrode to the shell. This type of spark plug resists fouling but is used in special high voltage systems.

Insulator Tip Spark Plugs

Insulation around the tip of an insulator tip spark plug (sometimes called projected tip or turbo action spark plug) extends farther into the combustion chamber than other spark plugs (Fig. 5.5). The tip is cooled by the cool, incoming fuel air-mixture then cleaned by the hot, outgoing exhaust gases. These plugs run hotter at slow speeds because of longer heat transfer distance and colder at fast speeds because incoming charges of cold fuel lower the temperature.

Fig. 5.5 - Insulator Tip Spark Plug

Fig. 5.4 - Resistor Spark Plug

Fig. 5.6 - Magnetic Field Around a Conductor

High Tension Leads

The high tension lead (Fig. 5.7) provides an insulated path for electricity from the coil to the spark plug. Because extremely high voltage is carried, the insulation must be very thick to avoid shorting.

Figure 5.7

How the ignition system works

When current flows through a conductor, a magnetic field builds up around that conductor (Fig. 5.6). If a conductor is passed through a magnetic field (or if the magnetic field is moved over the conductor) current will flow in that conductor, if there is a complete electrical circuit (Fig. 5.6). This principle is Electro-magnetic Introduction.

Magneto ignition systems use the principle of electro-magnetic induction to generate the electrical energy needed for ignition. Keep in mind that what appears to happen instantly is actually a series of steps, each taking only a few millionths of a second to complete, which generate enough voltage to jump the spark plug gap.

There are two kinds of magnetos used in ignitions: Three legged and two legged

Fig. 5.7 - Ignition Coil

Breaker Cam

Another type of breaker point assembly has the stationary breaker point on the end of the condenser (Fig. 5.9) points at the proper time of ignition. On two cycle engines (which require an ignition pulse or each revolution) the breaker cam may ride on the engine crankshaft. On four cycle engines (which require an ignition) the breaker cam (Fig. 5.8) opens and closes the breaker points every other revolution) the breaker cam may ride on the engine camshaft. Other systems use a plunger that rides on the crankshaft to open and close the breaker points (Fig. 5.9).

Figure 5.8

Figure 5.9

The condenser (Fig. 5.10) is an electrical capacitor made up of two layers of metal foil which are separated by an insulating material such as waxed paper. The metal foil and insulator are rolled up and inserted into a metal case. One of the metal foil strips is connected, with the condenser lead, to the primary coil. The other foil strip is electrically grounded, usually through the metal case. However, some condensers may have a separate ground lead.

As mentioned, some condensers have the field breaker point mounted on the end (Fig. 5.9).

Figure 5.10

Three-legged magneto

As the flywheel turns, the north and south poles of the permanent magnet begin to align with the first two legs of the iron core (Fig. 5.11). The moving magnetic field from the permanent magnet induce some current flow in the primary coil windings and through the primary circuit. No current flows in the secondary circuit because the spark plug gap prevents the circuit from being complete and the induced current is too small to jump the gap.

Figure 5.11 - Induced Current Flow

When the poles of the permanent magnet align with the first two legs of the iron core the greatest amount of current is induced in the primary coil (Fig. 5.12). The current flowing in the primary circuit creates a strong magnetic field around the primary and secondary coils. At the instant the magnetic field around the primary and secondary coils reaches its greatest strength, the breaker points open and stop current flow in the primary circuit. When current flow through the primary circuit is stopped, the magnetic field around the primary and secondary coils suddenly collapses. This collapsing magnetic field induces a high current in the secondary coil.

Figure 5.12 - Primary , Current Induced

Figure 5.13

Figure 5.14 - Current in Primary and Secondary

Figure 5.15 - Spark Plug Fires

Some current is also induced into the primary coil and circuit but is absorbed and stored in the condenser. (Fig. 5.14). The condenser helps reduce arcing across the breaker points by absorbing current when they first open, and as you will see, it serves to reverse the current flow in the primary circuit.

If we could stop the action of the magneto at this point we would find that the sudden collapse of

the magnetic field alone would not induce enough current in the secondary circuit to jump across the spark plug gap. The magneto must induce still more current into the secondary coil. It does this by reversing the procedure, that is by creating a rapidly expanding magnetic field.

When the magnetic force collapses to the point where the current induced into the primary is lower than the current absorbed and stored in the condenser, the condenser discharges its stored current back through the primary winding to ground. This rapid discharge of current, aided by the permanent magnet aligning with the second and third legs of the iron core, creates a strong, rapidly expanding magnetic field which travels through the secondary coil driving the current still higher until the current is strong enough to jump the spark plug gap (Fig. 5.15). The flywheel continues to rotate and the breaker points close.

Remember, this cycle takes place in just a few millionths of a second.

Two Legged Magneto

In the discussion of the flywheel magneto we showed how the magneto with a single magnet and a three-legged ignition coil core worked. Now we will describe how a magneto with two magnet and a two-legged coil works.

As the first magnet aligns with the two legs of the ignition coil core, the moving magnetic field induces current flow in the primary circuit. This current flow in the primary circuit creates a strong magnetic field around the primary and secondary ignition coils (Fig. 5.16).

When the magnetic field around the coils reaches its greatest strength, the breaker points open stopping current flow in the primary circuit. When the current flow in the primary circuit is stopped, the magnet field collapses rapidly building current flow in the secondary coil. The collapsing magnetic field also induces current flow in the primary coil which is absorbed by the condenser (Fig. 5.17).

When the magnetic force has collapsed to the point where the current induced in the primary coil is less than the current absorbed and stored by the condenser, the condenser discharges its stored energy through the primary coil to ground. At the same time, the second magnet, which has opposite poles from the first, moves into alignment with the legs of the iron core (Fig. 5.18).

Fig. 5.16 - Current Induced in Primary

Fig. 5.17 -Primary Current Stopped

Fig. 5.18 -Current in Primary and Secondary

Fig. 5.19 - Spark Plug Fires

The combination of the current generated in the primary by the rapid discharge of the condenser and by the moving magnetic field of the second permanent magnet creates a rapidly increasing, strong magnetic field through the secondary coil. This induces still more current in the secondary circuit until the current becomes strong enough to jump the spark plug gap (Fig. 5.19).

Maintenance and Repair

Prevent problems by performing the inspection, cleaning, lubrication, test, and repair procedures in the maintenance schedule published in the technical manual.

If the magneto ignition is not properly maintained; the engine can become hard or impossible to start, will not develop full power, and will waste fuel. In addition, a defective ignition system can cause severe damage to other engine parts.

Special Tools and Test Equipment

Testing ignition system parts and making ignition system repairs are all much easier when you have the proper tools and test equipment. The technical manual generally provides a list of special tools such as holding fixtures and flywheel pullers and commonly used pieces of test equipment such as:

- Continuity test light
- Coil tester
- Condenser tester
- Feeler gauge
- Millimeter

Isolate the Problem

When a machine is brought in with a problem, first find out what system is causing the problem. Many times an engine problem that appears to be caused by the ignition system is actually being

caused by something else; a faulty fuel system for example.

To determine if an engine problem is in the ignition system, answer two questions:

- is the ignition system developing a good spark?
- is the spark occurring at exactly the right moment?

If not take to a proper service person

If the answer to both of these questions is yes, the problem is in some other engine system. If the answer to either question is no, the problem is in the ignition system and you must find and repair the cause.

Small Engine Mechanical Systems

Four Stroke Crankshafts

The crankshaft is the part in the engine that turns reciprocating motion (up and down) into rotational motion (circular). The connecting rod fastened to the cranks offset throw and the other end to the piston. When the crank spins the throw makes a big loop. This loop is what pushes the piston up and then back down the cylinder.

Quite often there is an oil feed line through the crank shaft. The oil feed line and holes make sure that the connecting rod and main bearings are properly oiled.

The four stroke crankshaft is made in one piece. The connecting rod is bolted to the crankpin.

Four Stoke Crankshaft Service & Tips:

Check and see if all the bearings surfaces are round and smooth, there should be no grooves or scratches on them. Make sure that the oil feed line/holes are clean and will allow oil to flow freely. If the crank appears bent have it checked by a mechanic, if so you need a new crank. Make sure that the crank is not worn out. Check the crankgear to see that the teeth are not worn or broken. (l/2 size of the camshaft gear). If everything is good, polish the bearing surfaces with emery cloth to clean them up.

Figure 6.1

Two Stroke Crankshafts

A two stroke crankshaft is made in three pieces if it is a single cylinder. This is done because the connecting rod is slid over the crankpin and pressed together between the two crank throws.

Two Stroke Crankshaft Service & Tips:

Make sure the mag and PTO section of the crank are not worn, scratched or grooved (if ball/roller bearings are not used). Worn and scratched crankshafts could cause the crank seals to leak polish the crank with emery cloth and replace the seals. It is possible to replace only one piece of the crank, it is expensive and would have to be taken it to a machine shop to be done properly.

The roller/ball bearings can be removed from the crank if they need to be replaced. You will need a puller to remove them. If you have a twin 2 stroke the only way to replace the inside bearing is to take the crank apart. This would have to be done at a machine shop, it doesn't stop you from replacing the 2 outside bearings as mentioned above. Make sure that the crank is not bent or twisted. You can check it the same way as in a 4 stroke. You should take the crank to a machine shop to have it straightened.

Connecting Rod Service & Tips:

If the connecting rod is worn badly it will have too much oil clearance causing the oil to flow through to fast and will not be properly lubricated. If the connecting rod is too tight it will not get any oil, this will cause the rod to heat up and then it will seize to the crankshaft.

Check to make sure that the rod is not twisted or bent. Check to see that the two holes (Piston & Crank) are not worn out and are perfectly round. If the rod does not have bearing inserts, check to see that there are no scratches, lines or grooves in them. If so they must be replaced. Make sure that the oil feed line is clear, (on some 4 strokes).

Camshaft:

The camshaft is what opens and closes the valves. It also controls when the valves take in the air/fuel mixture and gets rid of the exhaust gases. A camshaft is a one piece unit that has a gear two times the size of the crankshaft and has 2 lobes per cylinder.

Camshaft Service & Tips:

Check to make sure that the camshaft is not bent. Check to see that the bearing ends are not worn. Check the cam lobes to see that they are not rounded off and that they are the same height.

***Note*:** Due to different engines the camshaft may be run by gears, chains, or belts.

Gears: Overhead or in head
Chain: Overhead
Belts: Overhead 1 or 2 camshafts (1 cam for intake valves, 1 cam for exhaust valves)

Cylinder (bore):

The cylinder(s) is where the piston makes its reciprocating motion (moves up and down). The cylinder must be almost perfectly round and straight up and down. The cylinder must be smooth and have no lines, scratches or major grooves.

Cylinder Service & Tips:

When you are putting a cylinder back into service you must first:

1. Remove the ridge from the top of the cylinder wall before you remove the piston. You have to do this because the piston rings do not come up out of the cylinder.
   You can remove the ridge with every cloth or with a proper ridge redeemer.

2. You must deglaze the cylinder wall if new rings are going to be installed. This is done by spinning a hone by a drill foot and moving it up and down the bore ???

3. After deglazing the cylinder you must put a cross hatch pattern on the wall to provide proper ring break in. You make a cross hatch pattern by using a cylinder hone. To do this must have

the cylinder hone in a variable speed drill, with the drill spinning slowly you move it up and down the cylinder until a 45 degree cross hatch is made.

4. After you are finished you must wash off the cylinder with **warm soapy water** to get rid of all the honing grit. This is **VERY IMPORTANT** any honing grit that remains will severly damage the engine.

Things to Remember on Cylinders:

Do not hone deglaze the cylinder too much because it will cause excessive piston cylinder clearance. The result of this is that the piston will slap the wall and this will cause the breaking of the piston springs and rings. Also the engine will have low compression and no power. The only way to fix it is to bore the engine out and go to an oversize piston and rings.

If an engine is bored too much the cylinder wall will become too think causing the cylinder to warp and then the block will have to be thrown away.

Coated cylinder boxes eg. (Nicasil) do not use a cast iron cylinder, these cylinders can not be bored or honed. Similarly aluminum cylinders cannot be honed.

2 stroke note: Chamfer all the ports in the cylinder wall.
Chamfer means rounding all sharp edges, this will prevent ring breakage.

The measure piston/cylinder clearance is:
The difference between the minimum cylinder bore and the Maximum piston diameter.

Bearings and Seals:

Reduces friction and keeps liquids and gases in place.

(1) Roller

(2) Ball

(3) Plain (inserts)

A roller and a ball bearing are almost the same except this one uses rollers and the other uses balls. Both of them are caged.

Roller & Ball Bearing Service & Tips:

Make sure that the bearing spins freely with no sticky spots do this by carefully twisting the bearing in your hand. Check and see that all of the cage is present. Check for cracks and hot spots in the bearing races. Replace bearing if anything appears out of sorts.

***Note*:** Never spin a bearing with compressed air. It could cause the bearing to fly apart.

Installing Ball Bearing:

New bearings can be installed by Heating the bearing in oil to a maximum temperature of 250 F. the bearing must not rest on the bottom of the pan in which it is heated. Place the crankshaft in vise with bearing side up. When bearing is heated properly it will become a slip fit on the crank shaft journal. Grasp the bearing with the shield down and thrust it down on the crank shaft as illustrated in Figure 6.3. The bearing will tighten on the shaft until cooled. **DO NOT QUENCH**!

Figure 6.2

Plain Bearing Service & Tips:

Make sure there are not any lines or scratches or grooves in the bearing face. Check to see that the coating is not coming off.

***Note*:** Never put a bearing together dry, always have oil or grease on it. Never store a bearing dry.

Seals:

There is usually a seal on the end of any shaft that comes out of an engine or gearbox. Make sure that there are no cuts/cracks or holes in the seal. Replace if the seal looks old or weathered. Do not over stretch a seal or o-ring. Make sure that the piston that the seal is going has all sharp edges removed and then polished with emery cloth. A leaky seal usually makes a stain. A seal can blow because there is pressure on the seal. A problem with 2 stroke seal is that a bad seal can suck air in and leak out the engine. This will cause serious damage to the engine often melting a hole in the top of the piston. If the seal won't go into place you might have to chamfer the hole where the seal is going

***Note*:** Never put a seal together dry, always have oil or grease on it

***Hint*:** You will know that you have the right seal or o-ring if:
The outside diameter is slightly bigger than the case & the inside diameter is slightly smaller than the shaft.

Always make a note where the old seal was placed so you can get the new one in the same place.

Rings: Are made out of hardened spring type steel

On a 4 stroke engine there are 3 rings

= top ring (compression)

= bottom ring (compression/scraper ring scraper edge for cleaning oil off the cylinder wall).

=oil control ring prevents excess oil from going up to the top of the piston and being burnt.

On a 2 stroke engine there are 2 rings.

= top compression ring (dykes ring)

= bottom compression ring.

Four Stroke Ring Service& Tips:

Make sure the rings have good tension. Make sure the rings are not twisted. Do not mix up the ring placement in the grooves. When positioning the rings on the piston they must be offset by 120 degrees from each other. The rings must fit into the grooves properly and line up with the locating pins.

***TIP*:** Before installing new rings you must first check the ring end gap. If there are any letters or numbers stamped on the rings, the letters / numbers must face the top of the piston when installed.

Valve Tappets & Lifters:
Lifters and tappets are pushed up and down by the camshaft. This is like the middle stage between the camshaft and the valves, but, these are what really moves the valves.

3 types: (1) Tappets
(2) Push rods
(3) Hydraulic lifters

***Note*:** Usually hydraulic lifters and push rods work together however there are engines that just have hydraulic lifters.

Tappet Service & Tip: Make sure that the ends and stems are not worn.

Push Rod Service & Tip: Make sure that the shafts are not worn/bent.
Make sure that the oil passage ways are clear.

Hydraulic Lifter Service & Tip: Replace when a new camshaft is installed or make sure that they hold oil pressure, (they do not rattle when running).

Valves:

These control how the fresh air/fuel mixture and the burnt gases get in and out of the engines cylinder(s).

A quick check:
the stem is not bent
The head is uniform
The margin in viable (1/32" to 1/64")
The face is not burnt or pitted

The face has to be smooth & uniform because good valve contact with the seat will provide:
1. heat transfer
2. good sealing (compression)

Valve Service & Tips: New valve and/or seat have to be lapped. Valve seat width should be: 1 mm intake and 2 mm for the exhaust valve. The valve seat is a 3 angle cut if needed, the top 30° - 32°
the middle 45° - 46° (the last cut), the bottom angle of the valve is 60°

Valve Clearance:

Is needed because the valve stem will get longer when the engine gets hot. To adjust calve clearance on a B & S and Tecumseh with no valve adjusters, you must grind the tip of the valve until the proper clearance is reached. The approximate clearance should be: 0.008" intake and 0.010" for the exhaust. The valve clearance must be taken when the engine is cold and the piston is positioned at (TDC) compression. On sport engines like, ATV, motorbikes and some lawn mowers. The valve clearance is done by a screw type valve adjuster. On sport engines like ATV motorbikes and some lawn mowers the valve clearance is done by screw type valve adjusters.

Valve Springs: The higher tension spring goes to the exhaust. The closely wound end is stationary (non moving) Res higher spring goes to exhaust again the closely wound end is stationary

Pistons: There are 2 types of pistons,

1. Cast pistons are made with molten metal poured into a mold they are most common and they are cheaper to make lighter in weight and heat expansion is less than a forged piston

2. Forged are made with metal hammered into a mold they are stronger & excellent for high

RPM in racing engines. The heat expansion is a large therefor need more cylinder - to piston clearance.

Piston Service & Tips:

Dark shadow below the rings is an indication of blow by which is caused by worn rings.Check to see that there are no holes through the crown of the piston. No broken/burnt ring lands. No lines or scratches/grooves on the piston skirt.

Use an old ring to clean the carbon out the grooves and then polish the grooves with emery cloth. When measuring piston clearance always do it at the bottom of the skirt because all pistons are wider at the bottom than at the crown.

*When installing wrist pin clips the open space must either face up or down. If the clip is put in any other way, the motion of the piston moving up and down could cause the clip to jump out.

The piston has a proper direction of installing, (check a service manual). Most of the time an arrow (±) will point towards the exhaust port or to the magneto side.

If the piston is oversized it will be stamped on the crown of the piston:
Ex: 0.010", 0.020" or 0.25 mm, 0.50 mm